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DOI: *10.17835/2076-6297.2019.11.1.144-154*

ИНСТИТУЦИОНАЛЬНЫЕ ДЕТЕРМИНАНТЫ ЭКОНОМИЧЕСКОЙ ЭФФЕКТИВНОСТИ ТЕПЛОЭНЕРГЕТИЧЕСКОГО СЕКТОРА

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В отношении развития энергетической отрасли России с точки зрения экономического кризиса и санкций, явлений на рынке и инвестиционных ограничений, методы управления активами тепловых электростанций приобретают особое значение. Становится очевидным, что для повышения жизнеспособности теплоэнергетического сектора энергетической отрасли необходимы определенные существенные экономические меры и реформы. Наша статья фокусируется на институциональных детерминантах развития теплоэнергетического сектора и его экономической и финансовой эффективности. Мы анализируем неоинституциональную теорию и ее применение в области реформирования энергетики на основе реорганизации нормативно-правовой базы и реструктуризации системы управлениятеплоэнергетическим сектором путем медленного сокращения монопольных функций производства и распределения электроэнергии. Кроме того, мы выясняем, привели ли незавершенные реформы электроэнергетики и возникшее в результате реформ оппортунистическое поведение электрогенераций к обострению неэффективности электроэнергетики.

Ключевые слова: *тепловые электростанции, структурно-технологическая модернизация, институциональная экономика, управление производством.*

INSTITUTIONAL DETERMINANTS OF THERMAL POWER SECTOR ECONOMIC PRODUCTIVITY

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In relation to development of the energy industry of Russia from the point of view of the recent economic developments such as, for example, economic and financial crisis, the phenomena in the market and investment constraints, as well as the issues of handling production assets and capital of electrical power corporations and enhancing the accuracy of development of thermal power plants asset management methods gain specific significance. It becomes apparent that certain substantial economic measures and reforms are needed for increasing the vitality of the power sector in general and thermal power plant sector in particular. Our paper focuses on the institutional determinants of the thermal power sector that are undertaken with a purpose of enhancing its economic and financial productivity. We analyze the neo-institutional standpoint which proclaims that reforming the energy sector involves reorganizing regulatory and governance frameworks involving market-based demand and supply conditions by slowly reducing the monopolistic features of manufacturing and distribution of power. Moreover, we investigate whether incomplete power industry reforms, or incompatible associations and associations originating out of reforms, have led to exacerbating power industry inefficiencies. Our results show that thermal power sector in Russia is in need of substantial re-organization and profound reforms that would increase its viability and economic productivity.

Keywords: *thermal power plants, technological change, institutional economics, production management.*

JEL classifications: *C67, Q40, L94*

Introduction

Thermal power sector and its institutional analysis constitutes an interesting and less-developed field of study that has not been explored neither by Russian nor by foreign institutional economists. Speaking about the thermal power in Russia, one can easily make

JOURNAL OF INSTITUTIONAL STUDIES ● Vol. 11, no. 1. 2019

an estimate about its economic significance. It would be sufficient to say that the installed capacity of power plants in Russian Federation is around 235 305 MW, of which 160 233 MW (about 68%) is provided by thermal power plants (TPP) (*ACGRF, 2019*). Therefore, it can be concluded that TPPs constitute the main share of electric energy production in the country. However, at the same time, in conditions of limited financial resources for upgrading the thermal power plant infrastructure, equipment deterioration reaches 74% which leads to an increase in repairs, risks of failures and accidents, and, accordingly, reduced safety and reliability of thermal power plants which confirms the urgency of with the management of the operation of thermal power plants with the existing problems.

Thus, one can see that thermal power plants (TPP) represent a considerable share of Russian electricity output and constitute a very important sector of the country's economy (*Lisin* and *Strielkowski, 2014; Lisin, Rogalev, Strielkowski* and *Komarov, 2015; Strielkowski* and *Lisin, 2016; Lisin, Sobolev, Strielkowski* and *Garanin, 2016; Lisin, Shuvalova, Volkova* and *Strielkowski, 2018*).

However, the majority of Russian TPP run on fossil fuels with a very little, albeit marginal share of renewables, which is very similar to the situation in the other countries, most notably in the United States (*Strielkowski, 2016*). The structure of energy and power sector is very important from the point of view of energy dependency and the economic growth of any country (see *Štreimikienė, Strielkowski, Bilan* and *Mikalauskas, 2016; Strielkowski, Štreimikienė* and *Bilan, 2017; or Rausser, Strielkowski* and *Štreimikienė, 2018*). Some researchers are using mathematical models to take measures of this dependency and to quantity it is using real values (see *Brożyna, Mentel, Szetela* and *Strielkowski, 2018*)

Just for the sake of the argument, the following comparison can be done. In 2017, approximately 63% of American electricity production was fossil fuels (coal, natural gas and oil), about 20% came from nuclear energy, and about 17% from renewable energy sources. Natural gas and renewable energy sources are responsible for increasing the share of American electricity production (similar results can be found on the data from the European Union (see *Newbery et al., 2018*), while coal production has declined.

In 1990, coal-fired power stations accounted for approximately 42% of the United States total electricity generation and approximately 52% of all electricity generation. In addition to that, EIA estimates that it will have 16, 224 MW of small-scale solar photovoltaics by the end of 2017, and the total electricity generated by small-scale photovoltaics was estimated to be around 24 billion KWh (EIA, 2019).

Power distribution sector quickly and efficiently, whereas other nations have taken a very long time to take first steps, has become the topic of intensive research (*Tankha, Misal* and *Fuller, 2010; Polemis, 2016*). Inconsistency in reform advancement between nations has been ascribed to dissimilarities in economic, political and social situation in national degree and gaps of endowments in sectoral level. Reviews of electricity and power sector reforms in developing nations, shows the gradual progress in reforms and their influences on the economic performance (see *Gratwick and Eberhard, 2008; Erdogdu, 2013; Erdogdu, 2014*). Pre-reform issues included shrouded in production capacity, inadequate funding, subsidized rates, higher transmission and distribution losses and wasteful general direction of the energy industry. These issues still prevail in many reforming countries, and sometimes they have even worsened.

Mainstream economic literature claims that a simple premise of classical economics (i.e. bounded rationality) is hard to attain in the real world (*Commons, 1931; Furubotn and Richter, 2005*). Early efforts to instil the institutional theory into mainstream economic theory faced objections from classical economists because of a scarcity of theoretical background. They did not violate New Cervical Economics but instead refined it by talking scenarios that it could not explain well (see *Arrow, 1963; Williamson, 1971; and North, 1979*). New Institutional Economics (NIE), headed by Douglass North, highlighted that western nations failed to achieve high economic development only on the grounds of owning high industrial manufacturing, but also because they'd better associations than less developed nations. Western nations shifted their economic, political, societal and legal associations over centuries, which helped them achieve rapid economic development when opportunities arose.

Our research focuses on the works of Douglass North (*North, 1990*) and Oliver Williamson (*Williamson, 1998*) a Neo-Institutional standpoint, reforming the energy sector involves reorganising regulatory and governance frameworks involving market-based demand and supply conditions by slowly reducing the monopolistic features of manufacturing and distribution of power. It involves altering the institutional environment and government arrangements by adapting and producing legislation, regulation and associations compatible with vulnerability to market requirements (*Bhattacharyya, 2007*). Multiple institutional structures which are oblivious, and those that do not favour market-based provide, are most likely to decrease the effect of sectoral reforms. In this paper, we investigate whether incomplete power industry reforms, or incompatible associations and associations originating out of reforms, have led to exacerbating power industry inefficiencies.

Thermal energy plants in the economic context

Due to the thermal energy storage, the load factor for all components of the thermal power plants in which the storage system is located increases. Otherwise, during periods of time without sunlight, the steam turbine of a solar system would become a water turbine and the solar gas turbine would receive a very low temperature gas that would cause serious thermal stress.

While in fossil-fired factories, heat transfer directly from flame and flue gas to the operating medium, some types of solar power plants use a separate heat transfer cycle. However, because the higher operating temperatures in the solar field also cause heat loss, the efficiency of the solar system as a whole does not increase as much as the energy block.

In addition, for the economic construction of turbines, the larger the size, the lower the capital costs per unit of power. The reliability of the steam plant includes a number of questions related to the design and analysis of such power generation networks.

Although there are many such applications, we will only focus on the use of graphical ideas to estimate the reliability index and evaluate the availability index for a coal plant.

We can construct a simple model of thermal power plants "release-release" of electrical (EE) – and thermal power (TE) resources is being developed. This allows us to create an economic-technological model that links the technology of tangible EE and TE assets of thermal power plants and the economic factors of financial assets: value added, profit, and payment of labour resources, from which the structure of the cost of ownership of a thermal power plant is derived.

Models of technological, economic and marketing states of technological-economic systems are a combination of some physical, technological and economic provisions and mathematical tools that allow to describe the most important characteristics of the considered states and patterns of temporal variations of these characteristics in the space of objects of the technological process.

Secondary and tertiary energy consumption occurs in the construction and maintenance of production facilities and equipment, the consumption and handling of raw materials, the disposal of waste and other activities.

In addition to the energy needed to produce the active ingredients, the energy used in formulation, packaging and transport can also be used to produce significant amounts of energy spent on the transfer of pesticides used by end users.

Analyses important or specific problems for the economy such as exhaustion, external, risk, manufacturing cycle, industrial structure, price, mineral role in development and trade, resource planning. Economic analysis of environmental pollution, conservation and management of resources, outdoor recreation, public land use, natural resources, water use, property rights and profitability.

Economic analysis of natural resources and environmental issues, the management of renewable and non-renewable resources and environmental facilities, market failures, outsourcing, profitability and risk analysis, property rights and the issue of “take” also represents an important aspect for this study.

It is possible for the economy to consume less energy for example, by using more efficient equipment, designing improvements such as reusing waste heat in the processes, or intelligently planning the production to minimise energy-intensive switching procedures. The empirical link between energy requirements and the production helps to make proactive production decisions and better manage energy investments in a way that leads to higher returns.

Once the economy establishes how much energy is needed to run a particular production cycle, it can use simplistic software tools to enter variables such as peak and off-peak energy costs, commodity costs, labour and projected emissions, and test “what – if” scenarios to see how production outputs and how the production outputs will be modified. For example, a North American packaging companies use the data on plant floor energy consumption to model energy consumption in all their shifts.

The introduction to the energy sector, including the use and development of fossil fuels and renewable energy, examines issues such as global energy production and consumption, energy efficiency, infrastructure, network and transmission, and the environmental and social impact of energy development with a focus on regulation, policy and gas industry.

It offers students an introduction to engineering in exploration and production, with a focus on processes related to oil and gas production, and its interface with land – based functions.

Synthesis of previous studies, focusing on the application of advanced concepts in finance, economics, law, regulation, merger and acquisition, negotiation, negotiation, construction, geology, engineering, title, leasing and environmental, as well as social and political issues.

Concerns about the use of crops for food versus fuel production, environmental impact of land use in connection with biofuels production, reduced oil prices, continued progress in wind and solar production, and political willingness to support and subsidise alternative energy development are of relevance and importance in this discussion.

However, if there is a stock of biomass, modern and more efficient technologies can be used to convert biomass or organic waste into energy with modest capital investments compared to the capital investment needed to produce fossil fuels. On the other hand, the development of fossil fuels or the production of solar or wind power leads to less jobs than biofuels production, and often fossil and solar wind jobs are not part of the local economy, and instead lead to a disproportionate number of jobs in the developed countries.

Energy management focuses on energy production with the aim of maximizing the direct and indirect benefits of energy production, in accordance with local conditions and policies. The climate models’ forecasts run in most developed economies show significant fluctuations in future water availability, which could affect wholesale electricity prices and the economic viability.

In the future, the demand for natural gas is mainly due to electricity production and household consumption. In addition to coal, oil, gas and electricity, the main source of energy for rural areas is biomass (plant and fuel). Hydro-technological and biomass energy are two major renewable energies used nowadays, and the use of other renewable sources such as solar and wind energy is relatively small.

Management Production Assets of Electric Power corporation

In institutional economic terms, one would probably agree with the postulate that energy suppliers will lead generation and centralised sales, and system integrators will focus on accommodating supply and demand peaks through the technologies currently distributed on the grid.

For example, thermal energy companies in the United States which serves industrial and commercial customers, offers demand reduction strategies that can help larger companies significantly reduce their electricity bills. Moreover, many business companies are already transferring their corporate positioning and models to distributed energy and other new parts of the value chain. Instead of selling electricity at the highest prices and to the highest bidders, they focus on energy management's energy efficiency and energy savings projects and use new channels such as social media to engage with customers.

Engineering and technology companies such as General Electrics in the United States and Siemens in Europe have long established themselves as planters in the larger segment of the distributed energy market. The transmission of electricity and distribution networks are key components of the state's security and defence. Therefore, this sector gains special importance in the economic development and should be treated as such.

In Europe, unlike other countries or regions around the world, the main challenge for the electricity sector is to improve the transmission and distribution system, not to change the energy source. In Germany, in particular, the first attempt was conducted to standardise large-scale energy aggregation agglomerates by combining energy companies, telecommunications companies and research centres through the so called "2008 E" energy programme. This is in accord with the Bloomberg's report on the digitisation of New Energy Systems published in November 2017 that highlighted the growing importance of smart grid technologies, particularly counters, in the global electricity market (*Midttun and Piccini, 2017*).

Moreover, there is also a so-called "Internet of Energy" (IoE) that constitutes an important part of the economic and social development of the power and energy industry. There are two examples of the use of the IoE in the electrical industry include monitoring and data acquisition (SCADA) and advanced measurement infrastructure (AMI). AMI is a key component of the "smart grid", consisting of home screens, home screens, power management systems, smart meters, communication networks and data management systems. Advances in computer science, database and analysis tools now allow predictive and prescriptive analysis to be applied quickly to large volumes of SCADA, AMI and data from other IoT commercial and consumer devices.

However, even with the IoE on the rise, energy companies have to fight their competitors, promote gas and electricity consumption as new devices enter the market and are pioneering the efforts of the local community to attract new businesses.

Well before the expected natural gas and fuel oil shortages for electricity production, energy companies have to start planning to take advantage of the extensive coal reserves. The management has to make sure that the co-ownership of power stations does not limit the flexibility of operations, so when demand forecasts forecasted the need for additional capacity (as it happened at the end of the 1980s and early 1990s), the decision can be made in favour of the construction of fully-fledged coal-fired power plants.

An important area of convergence is between electric cars and energy storage and manufacturing. The world-famous electric vehicles (EV) manufacturer, Tesla, uses the know-how and scales she has built to build advanced car batteries to deliver a new home energy storage product called the Powerwall, which can store excess energy from solar panels and provide backup power. Technologies such as electric vehicles combined with Internet applications are the basis for new transport systems in metro cities, including cars without driver. However, despite the international efforts to establish large electrical systems, there are still no standards for managing assets in the field of power. The inclusion of engineers and maintenance personnel, rather than company managers, in the management of planning assets, has also made it a priority to replace others by maximizing the availability of assets.

Instead, energy companies may have to purchase cost-effective business based on their capital management budgets or use simpler engineering models based on academic research (e.g., the algorithm for dissolving gas analysis in power transformers).

With this regard, it might be interesting to make a short empirical analysis of the dependence of the relative value of the asset on the values of the technological coefficient for various ratios of the value-added in thermal power sector. The analysis is presented below in Figure 1.

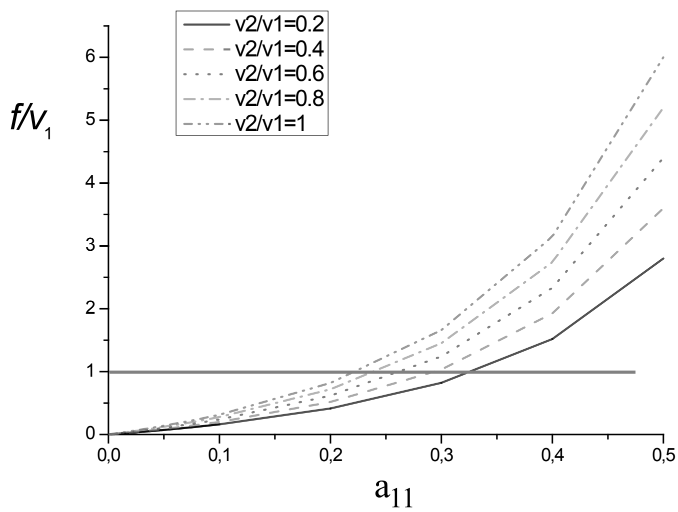

Fig. 1. Dependence of the relative value of the asset on the values of the technological coefficient (a11) for various ratios of the value-added sectors
Source: Own results

As one can clearly see, Figure 1 above shows the dependence of the relative value of an asset (f /v1), per unit cost of financial assets of the first sector, and the values of the technological coefficient of tangible assets (denoted by a11 and yielded as the share of equipment downtime and repair) for various ratios of value added or the value of financial assets of sectors (v2 / v1 = 0.2, 0.4 , 0.6, 0.8.1, and c2 / c1 = 1 and a21 = 0.5).

Figure 1 shows the marginal share of downtime and equipment repair (the point of intersection with the horizontal line f/v1 = 1) at which the value of the asset is equal to the value added of the resource unit. One can see that under these conditions, the operation of the equipment at the thermal power plant is not capable of generating any positive profit for the company that is running the plan in question.

Our analysis demonstrates that developed, involved, robust and complex systems (such as thermal power stations which are the focus of this paper) usually have a wide range of functions required.

Institutional framework of power sector reforms

An obvious consequence of the political interference in the energy companies' economic activity is that it has made the institution the weakest link in the power reform's value chain, with its unprofitable negative impact on independent energy producers, generation companies, distribution companies and ultimately on the acquisition of the crucial and needed investments in the energy sector.

Moreover, corruption is one of the main reasons for the collapse of the electricity industry in many countries and has therefore been the main reason for its reform. For example, in the United Kingdom, several high-level officials of the Rural Electrification Agency and the main members of the House of commons Commission were assessed by the Commission on Economic and Financial Crimes for allegedly wasting several billion dollars belonging to the national Electrification Agency. Unfortunately, these cases happen a way too often not only in the developing but also in the developed economies.

Local industry supervision authorities are standing on guard of the principles of pure energy market. They issue sanctions and approve the annual rate to be paid by the electricity end-users. and analyse all new investments in the industry by examining applications for concessions, licenses and permits before being granted by the respective departments.

In many cases, the question of which institution is responsible for coordinating and leading roles in the power industry is unclear. For example, power plants that build power lines are also responsible for effective monitoring and compliance with technical and operational standards.

The creation of other regulators is contrary to the philosophy of privatisation and limits the provisions.

If renewable energy were a part of rural electrification, any country (including Russia) would logically benefit from the TSO (transmission system operator) or the local distribution partners by making the surplus available. Except for the use of electricity without tender: a) if necessary and under the special conditions; ii) emergency, or iii) obligations of the state prior to the publication of the order; iv) for strategic industrial projects, subject to certain conditions and conditions. In addition to implementing electricity reform, the sector is expected to continue to develop two main lines: increasing production capacity and increasing access to electricity.

The provision of sufficient coal, gas or other sources of energy to produce electricity is crucial for achieving the objective of the country's electricity availability, affordability and accessibility. In fact, distribution companies have identified a lack of gas supply as a major challenge to tighten their finances, as it limits the power provided by generational companies.

With regard to the above discussion and applying the institutional economics toolbox to the energy regulation in general and thermal power sector in particular, one can examine terms linked to salary, expenses, rates, costs, subsidies and other temporary agreements supplied when the economy lacks a competitive pricing mechanism (*Williamson, 1981*). In becomes obvious that institutional reforms which go from state monopolies demand a restructuring of costs to make them market-driven and cost-reflective. Subsidies would have to be created more concentrated or abolished; and comparable conclusions enacted on other financial fronts to allow industry to flourish in a self-sustaining marketplace atmosphere. Representatives of the drastic and dramatic changes from inside the existing system and beyond the power industry may prefer institutional reforms (*Strielkowski, 2017*).

At precisely the exact same time, if there was a situation when a few people today were able to foresee a brand-new setup that would sabotage their pursuits, they could also create barriers to some shift in the institutional framework of the industry. If the next group gets stronger, then the machine may follow its prior track and might resist the reform. Institutional and financial endowments, as well the foundation of representatives and competitions, may ascertain the potency of path dependency. If endowments are powerful enough, they then might help to solve the issue of path dependence in a more immediate period, differently, dependence might be prolonged and transform into a gridlock situation which may call for radical steps to take and pursue with no remorse (see *North, 1990*).

Conclusions and implications

Power industry reforms are progressing gradually. Our results provide an institutional economics explanation of the main reasons for thermal power sector reforms in Russian Federation are hampered. Our research is based on specialist judgements which revealed that the specialists agreed on four institutional sources for the reform collapse: weakness of this government arrangement, weakness of their regulatory jurisdiction, sectoral endowments and declining actors in political associations. We propose the following changes which could have the capability to facilitate successful uptake of their reforms. Institutional endowments of the nation comprising constitution, administrative, legal, political and economic associations and the ideology ought to be transformed. These associations should be coherent and prevent duplication. Although changing these associations is quite a slow process which may only be hastened if most the stakeholders prefer market reforms in the Russian electricity industry.

One can see that progress in reforming the Russian thermal power sector may be quicker at the industry level. A nation-wide power law ought to be made with a consensus of those states to describe its working jurisdiction and make coherence with regional power laws. Each of the utilities in the nation ought to be controlled by one regulatory authority. The legislation ought to describe the working principles for the power markets, and character of regulatory associations containing regulatory governance and regulatory material.

Additionally, the legislation ought to include instruments for successful control of opportunistic behaviour from inside and beyond the power industry, rigorous legislation against power theft for the workers of the utilities and the customers, successful rules for the operation analysis of their utilities, efficient principles for tariff determination for all of the sections and advanced engineering and also an efficient mechanism for conflict resolution.

All in all, we show that institutional determinants of the thermal power sector have a considerable effect on its economic and financial productivity. Moreover, it becomes apparent that reforms in the energy sector are needed and these reforms should involve regulatory and governance frameworks centered on the market-based demand and supply conditions. These reforms can be carried out by reducing the monopolistic features of manufacturing and changing the distribution of power. Our results also demonstrated that incomplete power industry reforms might led to many disturbing power industry inefficiencies.

Therefore, it seems reasonable to conduct the reforms leading to the removal of obstacles hampering its steady institutional development. Economic theory is full of examples of reforms being blocked by unwise and short-sighted politicians. Thus, one has to make sure that this thermal power sector of Russian economy is treated in a different way that would ensure its optimal economic development and growth.

Acknowledgements. This paper was supported by the Ministry of Education and Science of the Russian Federation, research project No. 26.9593.2017/8.9.

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